

Feeding ecology of the Common Tree Frog (*Hyla arborea*) in a swampland, Western Hungary

By

T. KOVÁCS and J. TÖRÖK*

Abstract. We studied the food composition of 220 specimens of *Hyla arborea* in a swamp forest in Kis-Balaton Nature Reserve, Western Hungary, between 1993-1995. The diet of frogs basically consisted of insects, mainly Diptera, Coleoptera, Homoptera and Heteroptera. Araneidea was also found in high percentage in the sampled stomachs. By mass Gastropoda and Lepidoptera larvae made up a larger proportion of diet than by number. The diet of Common Tree Frog was more diverse in autumn than in spring or summer. Between years, similarity of food composition were around 50 %.

The Common Tree Frog (*Hyla arborea*) has wide geographical range in Europe. It distributes from the north-west part of the Iberian Peninsula to the western Ukraine and from southern Sweden to the Caucasus (GROSSE, 1994). *H. arborea* is a widely distributed but locally not abundant species of the Hungarian herpetofauna. It uses various microhabitats from the herb-layer to the canopy and changes them depending on seasons and ages of frogs. In our study area adults were found on the ground in early spring and in October. After mating they climb 5 or more meters up into the bushes and trees. Postmetamorphs and young juveniles forage on the ground or the lower bush-layer up to 2 m.

Similarly to other amphibian species, *H. arborea* is a generalist and opportunistic predator. As a consequence of this foraging strategy, the composition of its diet reflects the available food supply in the microhabitats where it forages. Although *H. arborea* is widely distributed in Europe few data have been published on its diet (BANNIKOV, 1985; CLAUSNITZER, 1986; JUSZCZYK, 1974). Some data has been published on the other species in *Hyla*, in other parts of Holarctic Region (JOHNSON and BURY, 1965; OPLINGER, 1967; FREED, 1988). It is, however, difficult to compare those findings with our results as the life history of those species, the used habitat, available food supply, and other variables differ from those in our Common Tree Frog population. Previous studies (LÖW et al., 1990; KOVÁCS and TÖRÖK, 1992, 1994, 1995, 1997; TÖRÖK and CSÖRGÖ, 1992; TÖRÖK and KOVÁCS, 1996) have shown a high level of consumption of coleopterans and dipterans in six studied non-hylid amphibian species in Kis-Balaton swampland area.

The predator-size/prey-size hypothesis predicts that larger predators usually forage for larger prey. This hypothesis has been tested in various type of predators including amphibians (GRIFFITHS, 1986; FLOWERS and GRAVES, 1995). This relationship usually

*Tibor Kovács and Dr. János Török, ELTE Állatrendszertani és Ökológiai Tanszék, Viselkedésokológiai Csoport (Department of Systematic Zoology and Ecology of the Loránd Eötvös University, Behaviour Ecology Group), 1088 Budapest, Puskin u. 3, Hungary.

exists in competitive communities where a range of sizes predator species occur. In the present study we tested whether size-related prey preference can be found within the population of *H. arborea*.

Materials and methods

Our study was conducted over three years, between 1993-1995. The study site was a swamp forest (Diás-Island) in the northern part of Kis-Balaton Nature Reserve. *H. arborea* occurred mostly on the trees in the edge zone of the forest and, with lower frequency, on the ground in open meadows. No specimens were found on the ground in the forest.

We collected frogs by hand. We used stomach-flushing (OPATRNY, 1980) to obtain stomach contents from the frogs. Prey items were preserved in 70% methanol, and then were identified to order or family level and their length (mm) was measured. We also measured the snout-vent length of frogs. Weight of prey items were estimated by three generalised weight-length indices (GOWING, 1984; ROGERS et al., 1976, 1977) and we calculated the percentage occurrence of prey groups by mass and by number. For comparing the diet in different years we used a proportional similarity index (RENKONEN, 1938). The diet diversity was computed using the Shannon diversity index (SHANNON and WEAVER, 1949). Seasonal changes in diet were compared only in 1995.

Results

We found large numbers of dipterans, coleopterans, spiders and aphids in the stomach of *H. arborea* (Table 1/a). Dipterans in the families of Culicidae and Chironomidae were extremely considerable in 1994.

There was seasonal change in diet composition (Table 1/b). In spring, frogs ate dipterans, coleopterans and spiders in high numbers, whereas in summer homopterans and dipterans dominated in the diet. In autumn the proportion of the dipterans decreased but gastropods, lepidopteran larvae and spiders appeared in higher numbers in *H. arborea*.

Considering the biomass of prey items asides from dipterans and coleopterans, gastropods and lepidopteran larvae also formed important parts of the diet (Table 1/a). The preferred prey groups by season were: spring, dipterans and coleopterans; summer, dipterans, lepidopteran larvae and gastropods; and autumn, lepidopteran larvae and gastropods. In spring of 1995 three dragonflies were eaten. They were extremely large ($x = 308$ mg) compared to other prey items and therefore dominated volume estimates of prey importance in the diet.

We found that, on average, smaller (juvenile) frogs fed on smaller prey and the larger frogs on larger prey (Fig.1). However, the minimum and maximum prey sizes were the same in the smallest and largest frogs. There was a significant, positive correlation ($r = 0.311$, $n = 209$, $p = 0.01$) between the size of frogs and the size of prey.

Diet diversity was the same in 1993 and 1995 ($H = 2.32$ for 1993, $H = 2.37$ for 1995) while in 1994, when dipterans formed more than 70 percent of the diet, diet diversity was quite low ($H = 1.52$). Diet diversity also showed seasonal variation. It was lower in spring and summer ($H = 1.85$ and $H = 1.86$ for the two seasons respectively) but higher in

Table 1/a. Percentage of different prey groups in the stomachs of *Hyla arborea* on Diás Island in three sampling years (N=by number, W=by weight, l=larvae)

Prey groups	1993		1994		1995	
	N	W	N	W	N	W
Gastropoda	1.8	13.2	0.7	6.7	5.7	24.4
Isopoda					0.4	0.0
Chilopoda					0.2	0.0
Collembola					0.2	0.0
Odonata					0.8	24.7
Orthoptera					0.2	1.4
Psocoptera					0.9	0.1
Physopoda					0.2	0.0
Heteroptera	8.9	3.4	4.7	3.0	3.8	1.0
Homoptera	1.8	0.7	0.2	0.2	5.5	1.7
Aphidina	12.7	1.4	0.7	0.2	0.8	0.1
Neuroptera			0.2	0.9	0.6	0.1
Coleoptera	26.0	15.4	7.7	6.3	10.6	4.2
Coleoptera l.	2.5	1.9	0.5	0.6	1.0	0.4
Trichoptera	1.3	14.0				
Lepidoptera			0.2	0.1	0.8	3.9
Lepidoptera l.	5.1	16.4	0.2	0.1	4.2	11.8
Diptera	18.3	12.6	75.5	72.3	42.0	19.1
Diptera l.	3.2	0.2	0.2	0.0	1.9	0.1
Hymenoptera	3.2	2.5	2.2	0.6	2.5	0.5
Formicidae	3.6	0.7	0.5	0.1	5.1	0.3
Pseudoscorpionidea	0.6	0.1	0.2	0.1	0.6	0.0
Opilionea			0.2	0.5	0.4	0.2
Araneidea	10.8	17.8	4.2	8.4	10.4	5.9
Acaridea			1.2	0.0	0.6	0.0

Table 1/b. Percentage of different prey groups in the stomachs of *Hyla arborea* on Diás Island in three seasons of 1995 (N=by number, W=by weight, l=larvae)

	Spring		Summer		Autumn	
	N	W	N	W	N	W
Gastropoda			5.0	27.7	14.7	49.8
Isopoda			0.6	0.1	0.7	0.1
Chilopoda					0.7	0.1
Collembola	0.4	0.0				
Odonata	2.0	65.3				
Orthoptera					0.7	4.0
Psocoptera			0.6	0.1	2.8	0.1
Physopoda					0.7	0.1
Heteroptera	2.0	0.6	2.8	0.7	7.7	1.6
Homoptera			15.0	5.7	1.4	0.5
Aphidina	0.5	0.0	1.2	0.1	0.7	0.0
Neuroptera					2.1	0.2
Coleoptera	17.6	4.8	6.1	7.2	6.3	1.4
Coleoptera l.	0.5	0.3	0.6	0.1	2.1	0.7
Lepidoptera			1.2	12.0	1.4	2.1
Lepidoptera l.	1.5	3.6			13.3	30.8
Diptera	48.3	18.5	58.3	41.3	12.6	3.1
Diptera l.	2.4	0.1	1.8	0.3	1.4	0.1
Hymenoptera	2.4	0.7	0.6	0.3	4.9	0.4
Formicidae	5.9	0.3	0.6	0.0	9.8	0.6
Pseudoscorpionidea	1.5	0.1				
Opilionidea			1.2	0.8		
Araneidea	11.7	9.2	4.4	3.3	16.1	4.4
Acaridea	1.5	0.0				

autumn ($H = 2.54$) because of the moderate proportion of dipterans. The similarities between the diet of the study years were quite low (0.41, 0.56, 0.58 between 1993-1994, 1994-1995, 1993-1995, respectively).

Discussion

In our study, we found that *H. arborea* fed on prey which typically found off the ground in higher vegetation. Stomachs of frogs collected on the ground (at the beginning and the end of their active period) were usually empty. Also, prey number per stomach was low in these individuals. Some prey types, such as earthworms, isopods, collembolans, chilopods and diplopods, which typically move on the soil surface and are usually present in the diet of other amphibian species in the study area, were almost completely absent from the stomach of these tree frogs (KOVÁCS and TÖRÖK, 1992, 1994). There was no evidence that these tree frogs feed on aquatic groups, as neither amphipods nor aquatic insects were present in the stomachs. In Germany, CLAUSNITZER (1986) analysed faecal pellets of *H. arborea* and found that dipterans and coleopterans dominated in the diet in summer (47.2 and 34.2 %, respectively). In our study, these groups dominated in the diet, but only if spring, summer and autumn were combined; they did not dominate if only summer was examined. In summer, homopterans were more numerous than coleopterans in Diás-Island. In autumn, other groups, such as gastropods, lepidopteran larvae, ants and spiders also occurred in higher number than did coleopterans in the diet of frog diets.

Comparing the diet of *H. arborea* to the other anuran species living in Kis-Balaton we found notable differences (KOVÁCS and TÖRÖK, 1992). The highest similarity in diets (0.74) was between *H. arborea* and *Rana esculenta* complex (unpublished data of 1995) because the latter species also ate large numbers of dipterans and coleopterans. Edible Frog forages mainly during the daytime and very often in open sites where dipterans were common. Edible Frog uses several microhabitats, such as forest ground, meadows, river banks, reedbeds and open water. Because of it, many other prey groups were present in its diet, i.e. earthworms and aquatic isopods. We found the lowest similarity between *H. arborea* and *Bufo bufo* (0.28) in 1995. Common Toad is a nocturnal predator, and its diet consists of mostly apterous or weakly flying groups. Dipterans formed only 10.7 % of the diet. Diet composition of other anuran species (*Rana arvalis*, *Bombina bombina*, *Pelobates fuscus*) shown moderate similarity to Common Tree Frog's diet.

Seasonal changes in diet composition was probably correlated to variations in resource supply. When a prey group dominated in the habitat, it also formed a higher proportion of the diet. For example, dipterans were common in spring and summer and non-aphid homopterans were common in summer. The high diet diversity in autumn was the result of more generalised feeding, in which dipterans played a much smaller role. Our studies in 1992-93 on seasonal change of diet diversity in *R. esculenta* c. shown a different result from that found in the Common Tree Frog (KOVÁCS and TÖRÖK, 1994). In Edible Frog, diet diversity was almost the same in the three seasons (spring: 2.59, summer: 2.40, autumn: 2.50). There was no prey group which dominated as strongly as did dipterans in *H. arborea*. Because of its unspecialised microhabitat preference Edible Frog can change its forage sites easily following a change in prey supply. However, Common Tree Frog are tree-climbing specialist and unwillingly leave the canopy.

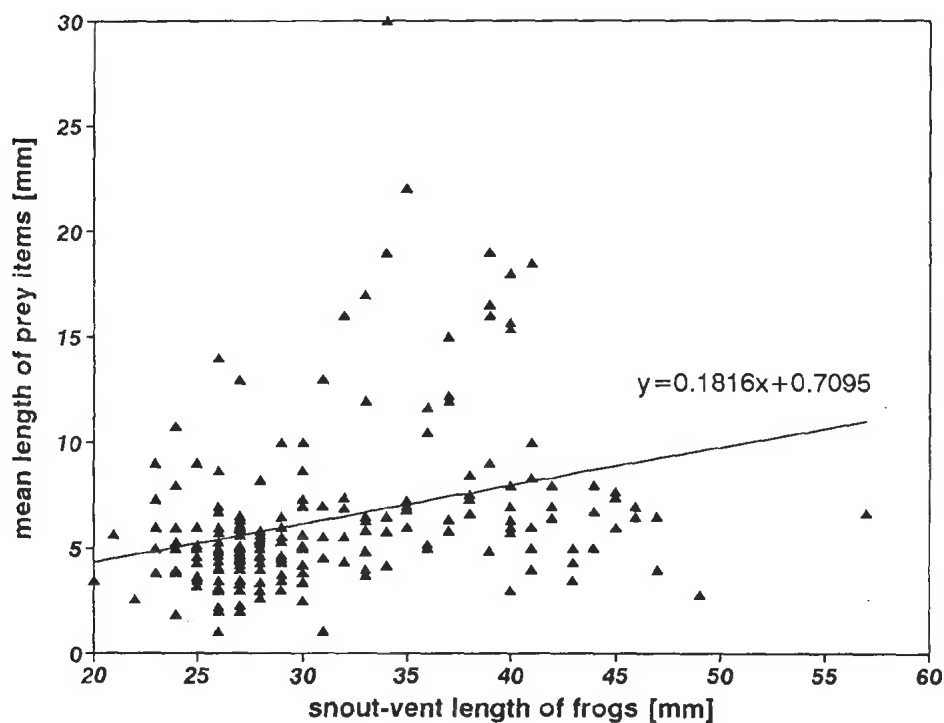


Fig. 1. Predator size dependent prey sizes in *Hyla arborea* in Diás Island, 1993-1995

There is only a moderate difference between the size of postmetamorph juveniles (20-25 mm) and adults (40-50 mm) of *H. arborea*. As a result, there are only slight differences in the prey utilised by these two size groups. LÖW (1990) found much larger prey sizes were eaten by larger specimens of *R. esculenta* and *R. arvalis* in which snout-vent length of postmetamorph juveniles is 20-25 mm whereas 4-years old adults grow up to 70 mm or more.

Summing up our results, although *Hyla arborea* eats a large variety of prey groups its diet consists of mainly dipterans and coleopterans. We observed seasonal changes in diet composition which connect not to differences in microhabitat use of Common Tree Frog but to the availability of prey supply. As the predator-prey size hypothesis predicts, there was a positive correlation between frog size and its prey size.

*

We are indebted to B. CSER, S. FIAR, Cs. GERGELY, A. LELKES, and M. NÉMETH for help in field and to I. SONNEVEND for permission to work in the protected study area. The work was funded by the Hungarian National Research Fund (#499 to G. GERE, 2232 and 17058 to J. TÖRÖK), a Fund of Balaton Limnological Institute of HAS, Council of Kaposvár city. During this study T. KOVÁCS received a fellowship from Hungarian Credit Bank.

REFERENCES

1. BANNIKOV, A.G., DENNISOVA, A., DARWESKI, I.S., ISCHTSCHENKO, W.G., RUSTAMOV, A.K. & ŠERBAK, N.N. (1985): *Zin zivitnych. – Zemnovodnye presmykajusjesja*, Moscow.
2. CLAUSNITZER, H.-J. (1986): Zur Ökologie und Ernährung des Laubfrosches *Hyla a. arborea* (L., 1758) im Sommerlebensraum. – *Salamandra*, 22 (2-3): 162-172.
3. FLOWERS, M. A. & GRAVES, B. M. (1995): Prey selectivity and size-specific diet changes in *Bufo cognatus* and *B. woodhousii* during early postmetamorphic ontogeny. – *J. Herpetology*, 29(4): 608-612.
4. FREED, A.N. (1982): A tree frog's menu: Selection for evening's meal. – *Oecologia*, 53: 20-26.
5. GOWING, G. & RECHER, H.P. (1984): Length-weight relationships for invertebrates from forests in south-eastern New-South Wales. – *Aus. J. Ecol.*, 9: 5-8.
6. GRIFFITHS, R.A. (1986): Feeding niche overlap and food selection in Smooth and Palmate Newts, *Triturus vulgaris* and *T. helveticus*, at a pond in Mid-Wales. – *J. Anim. Ecol.*, 55: 201-214.
7. GROSSE, W.-R. (1994): Der Laubfrosch. – *Die Neue Brehm-Bücherei Bd.*, Magdeburg: 16-20.
8. JOHNSON, C.R. & BURY, R.B. (1965): Food of the Pacific Tree Frog, *Hyla regilla* Baird and Girard, in northern California. – *Herpetologica*, 21 (1): 56-58.
9. JUSZCZYK, W. (1974): *Plazy i Gady krajowe*. – Warsaw.
10. KOVÁCS, T. & TÖRÖK, J. (1992): Nyolc kétélű faj táplálékösszetétele a Kis-Balaton Természetvédelmi Területen. – *Állatt. Közlem.*, 78: 47-53.
11. KOVÁCS, T. & TÖRÖK, J. (1994): Kétélű fajok táplálékpreferenciájának szezonális változása a Kis-Balaton Természetvédelmi Területen. – III. Magyar Ökológus Kongresszus, Szeged, 1994. Abstract.

12. KOVACS, T. & TÖRÖK, J. (1995): Diet plasticity of the Edible Frog (*Rana esculenta* complex) in a protected wetland area in Hungary during a 9-year period. – 7th European Ecological Congress, Budapest, 1995. Abstract.
13. KOVACS, T. & TÖRÖK, J. (1997): Minimal sample-size to estimate the diet diversity of anuran species. – *Herpetol. Journal*, 7. (In press.)
14. LOW, P., TÖRÖK, J., SASS, M. & CSÖRGÖ, T. (1990): Feeding ecology of amphibians in the Kis-Balaton Nature Reserve. – *Állatt. Közlem.*, 76: 79-89.
15. OPATRNY, E. (1980). Food sampling in live amphibians. – *Vest. Cs. Spolec. Zool.*, 44: 268-271.
16. OPLINGER, C. S. (1967): Food habits and feeding activity of recently transformed and adult *Hyla crucifer* Wied. – *Herpetologica*, 23 (3): 209-217.
17. RENKONEN, O. (1938): Statistische-okologische Untersuchungen über die terrestrische Käferwelt der finnischen Bruchmoore. – *Ann. Zool. Soc. Bot. Fenn.*, Vanamo, 6: 1-231.
18. ROGERS, L. E., HINS, W. T. & BUSCHBOM, R. L. (1976): A general weight vs. length relationships for insects. – *Ann. Ent. Soc. USA.*, 69 (2): 387-389.
19. ROGERS, L.E., BUSCHBOM, R.L & WATSON, C.R. (1977): Length-weight relationships of shrub-steppe invertebrates. – *Ann. Ent. Soc. USA*, 7: 51-53.
20. SHANNON, C. E. & WEAVER, W. (1949): The mathematical theory of communication. – Univ. Illinois Press, Urbana.
21. TÖRÖK, J. & CSÖRGÖ, T. (1992): Food composition of three *Rana* species in Kis-Balaton Nature Reserve. – *Opusc. Zool. Budapest*, 25: 113-123.
22. TÖRÖK, J. & KOVACS, T. (1996): Táplálékösszetétel és -diverzitás változása a kis-balatoni békáknál 1985 és 93 között. – *Állatt. Közlem.*, 81. (In press.)